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HOW TO ROBETELL THE WEATHER WITH THE POCKET SPECTROSCOPE

F W CORY





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HOW TO

FORETELL THE WEATHER

WITH THE

POCKET SPECTROSCOPE

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WITH TEN ILLUSTRATIONS.

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HOW TO

FORETELL THE WEATHER.

In commencing an account of some new subject, it is customary to quote its history; but that of the rainband, one of the most important features in the sky spectrum, and the first noticed, has been so frequently referred to that it would be a matter of supererogation on my part to adduce what is now so generally known. Suffice it to say that in 1872 Prof. Piazzi Smyth, the Astronomer-Royal for Scotland, was the earliest to draw correct conclusions from its appearance.

The subject of which we are about to treat depends mainly upon the amount of invisible

aqueous vapour contained in the atmosphere. Visible vapour influences the spectrum but slightly, and then only by reflected light. The records of hygrometry extend back for more than three hundred years. Mizaldus, in 1554, and Mersenne, in 1644, both noticed that the pitch of the strings of a violin varied according to the dryness of the air. The former says,* 'Musicorum instrumentorum subtensæ fidiculæ ruptim dissilientes, et hostia absque manifesta causa, aperiri claudique solito contumaciora, aerem pluvias nobis miscere palam nuntiant; literally meaning, 'The strained strings of musical instruments suddenly snapping, and sacrificed victims, without any apparent cause, opening and closing, and becoming more stiff than usual, plainly tell us that rains are disturbing the atmosphere.'

Even Pliny the elder, who lived A.D. 23 to A.D. 79, seems to have been a rough observer

^{*} Mizaldus, A., 'Ephemerides Aeris Perpetuæ.' Small 8vo. Lutetiæ, 1554.

of the dew-point, as instanced in the following quotation from the eighteenth book of his 'Historia Naturalis': 'Nec non in conviviis mensisque nostris vasa quibus esculentum additur sudorem repositoriis linquentia diras tempestates prænuntiant; which, translated, is: 'And also at banquets and at our tables, vessels in which there is any esculent moisture left on the trays foretell fearful storms.' Of all the numerous moisture-absorbers that man has applied his ingenuity to in adapting to the purposes of hygrometry, such as the beard of the wild oat; beard of musk grass, or geranium moschatum; internal membrane of the arundo phragmites; skin of the frog; Dutch weather house; schistose stone, a material so porous that when saturated it weighs nearly half as much again as when dry; and then the more modern and scientific instruments, viz., Daniell's, Regnault's, and Dines' hygrometers; and lastly, Mason's dry and wet bulb hygrometer, that is used more frequently than any

other at the present time (and which, by-thebye, was invented by Boeckmann nine years before Dr. Mason was born), together with a great many others constructed of animal, vegetable, and mineral substances. Of all these, not one has the power of indicating the state of atmospheric moisture for more than a few yards around the instrument; but there is one that will inform you of the state of invisible moisture of a section of air many miles in thickness, the penetration depending on the amount of visible moisture present at the time of observation.

The following classification suggested by Pouillet is not perfect, but will do for all ordinary purposes. He divides them into:

- 1st. Hygrometers* (or hygroscopes†) of absorption.
- 2nd. Hygrometers of condensation, *i.e.*, dew point instruments.

^{*} ὑγρός (hugros), damp, and μέτρον (metron), measure. † ὑγρός (hugros), damp, and σκοτέω (skopeo), to look at.

- 3rd. Hygrometers of evaporation, *i.e.*, dry and wet bulb thermometers.
- 4th. Chemical hygrometers, for determining the amount of vapour by analysis.

 And I think we might now add to these the hygro-spectroscope, or rainband spectroscope.

During the last few years this new form of hygrometer has been rapidly advancing in popular favour; but a want has been felt by many an observer, which it will be my endeavour, in the following pages, to supply in as brief, plainly worded, and exactly described manner, as will tend to assist the tyro in his preliminary difficulties, with the manipulation and deductions therefrom, of an instrument of such fine and delicate research.

There are two spectroscopes at present in use, both of moderate dispersion; one, called 'The Rainband Spectroscope,' is an excellent little instrument, very portable, and to a

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skilled and careful observer reliable for forecasting.



Fig. 1.

The other, named 'Grace's Spectroscope,' now becoming the favourite, is larger, but with the same amount of dispersive power; the increased size of the spectrum in it is of



Fig. 2.—Spectroscope with attached Micrometer.

great utility in clearly defining lines and bands, besides the advantage of being able to use it earlier and later in the day than the former kind, on account of the greater amount of light admitted.

In several other respects it differs from the first; it has a milled wheel, with lever for adjusting focus, and instead of plain glass nearest the eye, a concave lens is fitted.

Mr. Browning, the eminent optician in the Strand, has fixed to my Grace's an adjustable photographic micrometer, with prism of comparison. This combination makes the perfection of an instrument for meteorological purposes.

It would be as well now to proceed to a



Fig. 3.

description of the 'Rainband Spectroscope,' which, with the above exceptions, will equally apply to the other instrument.

It is composed of two cylinders, one fixed and the other movable, the latter sliding within the former; at the further end of the fixed portion, which is $3\frac{1}{2}$ inches in length, the aperture is covered with a cir-

cular piece of microscopical glass, and just within this are two parallel jaws, adjustable by means of a milled wheel outside, to admit more or less light, according to the requirements at the time of observation. The movable part, $2\frac{1}{2}$ inches long, has at the extreme end a collimating lens to collect the light which passes through the slit, and to throw it in parallel rays upon the prisms placed

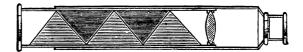


Fig. 4.—Section of Direct Vision Spectroscope.

behind it. These prisms are five in number: one, three, and five are made of crown-glass, two and four of flint-glass. (Vide Fig. 4.) They are all cemented together, and the effect of this combination is to give an image of the prismatic spectrum of sufficient dispersion to show the position of the dark lines, both constant or solar, and variable or telluric—that is, due to vapour in our atmosphere.

Between the prisms and the eye of the observer is another disc of glass. The total length of the instrument when closed is $3\frac{3}{4}$ inches, and its diameter $\frac{7}{8}$ of an inch; while Grace's is $\frac{15}{16}$ of an inch in diameter, and $5\frac{5}{8}$ inches long when closed.

In taking an observation with either instrument, shade the eyes with the hands in such a way that all extraneous light may be excluded as much as possible. It is of the highest importance to adjust the focus and slit of the spectroscope so that the lines in the spectrum may be of the clearest definition, and when once adjusted it seldom requires altering. I would recommend the beginner to focus either the poline in the orange part of the spectrum, or the E line in the green (vide Plate of Spectrum); and when he becomes more at home with the instrument, he will find no difficulty in rapidly and clearly defining any visible line in other parts of the prismatic spectrum.

The inner sliding-tube ought to be slightly

pushed in for examining the blue end, and drawn out a little for focussing lines in the red. avoid loss of time in focussing, it is a good plan to mark the inner sliding cylinder with the edge of a knife, in the same manner as is frequently done to telescopes. If the slit be closed too much, horizontal lines parallel to the length of the spectrum will probably make their appearance; in almost every case they are due to the presence of dust on the edges of the slit. To remove this dust, open the slit as widely as possible, and wipe the edges with a small wedge of dry wood-an ordinary lucifer match cut into this shape will answer the purpose. Then close the slit completely; re-open it, and the lines will probably have disappeared; if not, repeat the operation. Note that a camel-hair pencil, a leather, cloth, piece of paper, or blowing on it, will be sure to make the slit worse. Frequently, simply taking off the cap from the slit and moving the focussing tube in and out quickly will

blow the small particles away. Sometimes, whilst observing, moisture by condensing on the eye-piece will somewhat obscure the spectrum; to counteract this, warm the near end slightly either before the fire or sun, or by applying it to the warm skin.

In a general way, observe from ten to twenty degrees above the horizon, and towards the quarter from which the wind is blowing or likely to change to. As regards the latter point, it is much easier to forecast the probable direction of wind from movements of upper clouds, fluctuations of the barometer, etc., than it is to foretell rain.

The best hours for examining the general characteristics of the spectrum are 9 a.m. and 3 p.m., all the year round. In computing means, for various reasons it is not advisable to alter these hours, as by so doing errors are obviously liable to creep in. The focus and slit having been correctly adjusted, compare the lines and bands as seen in the spectrum

with their relative positions as delineated on the chart (vide Plate I.), A, a, B, C, D, E, b, F, G, are constant and invariable solar lines; a, B, C, c', α , r, δ , v, w, variable lines and bands; B, α , δ , dry air lines, or low sun bands; a, c' r, v, w, rain bands; r, position of principal rainband.

A, a, and B, are best studied by looking direct at the sun; for in ordinary daylight B is not always well defined, a still less so, and A never, but, notwithstanding, is occasionally just visible. A is of no meteorological value, and changes very little for either high or low sun. It is not known what gas or metal in a gaseous state it represents in the sun; this remark likewise applies to B. 'Neither of them are telluric lines, nor due to aqueous vapour, but must originate between the sun and our atmosphere' (Prof. Piazzi Smyth). The preliminary band of B is intensified with a low sun, and diminished with an increasing altitude. It is spoken of as a dry-air or low-

sun band. The physical origination of the darkness of the band at a is due to an invisible gaseous state of intensely watery vapour contained more or less in the lower part of the earth's atmosphere (Smyth). A comparison of the dark shadings at a and B ought always to be made, if possible, when the sun is shining at a low altitude. c is the red hydrogen line; the lines about it with low sun are probably due to water vapour. At c' is situated a small rainband.

The ∞ line must be produced by one of the permanent gases of the earth's atmosphere. The band at this position is telluric; a low-sunband and of a dry-air character. Its variations are of great importance in forecasting rain or fine, being very conspicuous before dry weather, and on the other hand weak in intensity previous to wet; on one occasion, when unusually distinct, fine and dry weather prevailed over the whole of Western Europe (Prof. Smyth).

Next in order is the principal rainband at r, situated on the red side of the D lines, which I will subsequently refer to more in detail. In the yellow strip on the other side of D a line is frequently seen when the spectrum at this part is unusually clear; consequently, before snow, when the vapour lines have been considerably weakened from the transformation of the invisible vapour into snow crystals, this line (really made up of several lines, including barium and calcium) will be very prominent, at times exceeding in darkness the lines in the rainband. The dryair band at & is a marked feature when the sun is low, and merges more or less into the moist air shading at v, and on the other hand, should the latter be strong, for instance, before a thunderstorm, it will be found to encroach on the shading at δ, a remarkable phenomenon, the rationale of which is rather difficult to satisfactorily explain. The line E is one of the many that represent iron in the sun. The b lines indicate the presence of magnesium, nickel and iron. The distinctness and definition of these important dark lines are of some value in the prevision of weather, as before heavy rain they are more or less involved in the darkness that envelops the violet end and almost obliterates the blue hydrogen line, F, in the glaucous, or sea-green coloured, region of the spectrum. The g group can be generally seen in ordinary daylight, and is a useful guide as to the clearness of the spectrum; this is the last set visible in 'small spectroscopes, but in Grace's, on several occasions of very clear atmosphere with a bright sun, I have succeeded in sighting the н lines in the lavender. Many persons mistake the G group for the H, which cannot be distinctly defined, even in large instruments of the prism variety.

THE RAINBAND.

The principal rainband is situated on the red side of the D lines, involving them, and at times increasing or decreasing in intensity, and approaching or receding from the c line, according to the nearness or quantity of rain. In spectroscopes of small dispersion it exhibits itself as a dark shading; in larger instruments this band will be split up into a quantity of fine black lines (vide Plate II.).

Observers who have closely watched this band will no doubt have noticed great variations in its appearance—at one time being narrow and condensed, or broad and extended; at other times almost uniform in darkness, or rapidly shading off, or exhibiting itself as two dark lines to the red side of D, with one bright interval frequently between them, and another in the space between the more refrangible towards the green and D (Grace's spectroscope shows these lines exceedingly well). When they are strong and wellmarked, they may certainly be taken as indicative of heavy rain. A thickness and darkness about the D lines alone must not be

considered as a reliable rain prognostic. This illusory appearance leads people frequently to mistake it for the rainband proper, and to give it a greater value for rain than it sufficiently warrants. Undoubtedly, when the p lines are thickened, invisible vapour is the cause of it; but the two sets of lines on the red side of them are those to take into account in prevising rain.

In a great many anti-cyclones I have noticed this false band to be present. The rainband in many cases gradually increases for some time before rain. If it remains persistently high for several days, without rain falling in proportion, as much as a week perhaps of wet weather will follow. An increase in the percentage for the season of the year is suspicious of wet: in summer or warmer weather the rainband is higher than in winter or cooler weather; for example, 40 per cent. has a greater value for rain in the latter than in the former. Most of the

cyclones or depressions that cross England from the Atlantic bring with them a large body of air saturated with moisture. It is interesting to gauge their individual proportion of rainband: a small number have 70 or 80 per cent., a very few only 20 or 30, but generally 50 or 60. In the rear of a depression, as a rule, periodical showers occur; the air being cleared from the previous gale or heavy rain, they can frequently be seen for several hours beforehand with the spectroscope, but not with the naked eye.

Sometimes, during rain, the amount of rainband may be low: this for the most part denotes finer weather to follow; if, on the other hand, strong, it merely shows either that more rain is to follow, or the spectroscope is unable to penetrate the rain then falling and analyze the light on the clear side of the shower. Should there be a very heavy mist at the time of observing, its telescopic power will not be of much value. It would be too

much to expect of a spectroscope to sift the light of several miles of visible aqueous vapour; in such cases it is more on a par with the hygrometers, that are only serviceable for a few surrounding yards of rain. Intensity of rainband does not presage the fall of snow; on the contrary, the reverse does.

Mr. Capron, in his widely-known and excellent little pamphlet, 'A Plea for the Rainband,' has stated that the rainband is low during cold winds. I can corroborate this statement; and would add, that generally speaking the rainband gradually diminishes for several days before snow. It seems that the vapour is transformed into snow-crystals; and I have no hesitation in saying that in those cases, when with a low percentage of rainband, rain apparently falls, it is either melted snow or hail; which is proved by the fact that frequently, as the precipitation increases, the rain decreases and only snow or hail is seen—for in these cases it is highly probable that

the snow becomes melted in its passagethrough a warmer substratum of air, and as the temperature of this is gradually lowered by the snow, so we find an increase of the latter and a diminution of the rain.

If the spectroscope be directed towards the point from which the wind is blowing, and should the clouds be passing in one and the same direction, and 20 per cent. or less of the rainband be shown, no rain will follow for at least six hours, in spite of any threatening appearance of the sky.

In estimating low percentages of rainband, it is advisable to look direct at the yellow, so as to see the band slightly askew; by doing so any shading in that situation will easily become perceptible. Through observers not following this simple rule, one can quite understand how it is that frequent cases of 'no rainband visible' are entered on their charts or in their note-books. Such an absence of vapour lines seldom occurs, to my

knowledge. On one occasion that Professor Smyth observed a disappearance of all the rainband lines, a period of cold and dry weather succeeded. It has never been my good fortune to note a total absence of rainband; twice or three times the shading has been so slight as to be barely recognised. In the other extreme of percentage—for example, where 80 per cent. is seen, the darkness of the band is so extremely wellmarked as to form a most conspicuous feature in the spectrum; should such an amount be visible at the zenith, rain will certainly fall heavily before long. Possibly every observer, without exception, may at times be rather at fault in the calculation of the quantity of rainband. The use of a mental scale, which one must of necessity have recourse to, cannot be considered infallible. To compare the darkness of the rainband with the permanent lines of the spectrum will prove impracticable if Grace's spectroscope be used; it might do

for instruments of very small dispersion, but these are not to be recommended as hygrospectroscopes. As far as I know, Grace's is decidedly the best instrument for this purpose; and fitted up as I have already mentioned, with a prism of comparison and micrometer, the meteorologist may feel assured he is possessed of an apparatus of immense practical value.

Mr. Rand Capron, in enumeration of the darkness of the rainband for the purpose of record, uses a scale of from 1 to 5, as follows: 1 means faint; 2, faint to moderate; 3, moderate; 4, moderate to strong; 5, strong. Professor Smyth recommends and employs from 1 to 10—which I adopted for some time, until I could recognise intermediate shading, and have now for more than a year found a division of the scale into 20 parts as much as it is possible to accomplish. A difficulty will sometimes be experienced in ascertaining the percentage at the zenith in certain atmospheric

conditions when the sky blue is very deep and dark; it certainly is not an easy matter, and all the careful manipulation and perspicacity at the command of the observer is requisite. It must be borne in mind that the rainband is quite independent of peculiar forms and characteristics of clouds indicating fine weather or the reverse.

Many cases have happened where a strong rainband has been noticed on a blue sky, with every appearance of fine weather for at least twelve hours, and rain has subsequently fallen within that time; or a very small percentage has been seen with most threatening clouds, that seemed as if they must shortly pour forth torrents of rain, yet it did not occur. Showers of rain may be very localized, and have a tendency to take certain routes, passing perhaps within a short distance of an observer, who, from the large amount of rainband visible at that time in the spectroscope, may prognosticate the rain that never reaches him;

and unwisely conclude, because it does not fall in his immediate locality, that therefore the instrument is worthless as an aid to forecasting. Such reasoning is clearly fallacious. At first, when I was endeavouring to prove to my own satisfaction the connection between rainfall and rainband, I could not help feeling disappointed at what I considered absolute failures as regards the value of this band as a fore-runner of rain; but, thanks to the information given by friends, reports in papers, and by searching for evidence of rain having fallen in the neighbouring country, with the help, I ought to add, of that modern invention of proved utility, the tricycle, I was enabled to entirely put aside these misgivings, and rest satisfied that what had been claimed for the spectroscope was no mere chimera of the imagination, but the commencement of a fresh branch of meteorology that would eventually supply the missing link in forecasting, annihilate its difficulties, and bring to our knowledge facts about the upper regions of the atmosphere that were never dreamt of in our philosophy.

Again, it is possible for a cloud to deposit its shower before reaching the observer; and by his following the rain-cloud with his spectroscope he will in some cases become sensible of a diminution in the rainband after it has passed, and perhaps perceive what has astonished me in one or two instances, and that is, an actual increase in the band as the cloud recedes. What can be the cause of this increase? Is it an aggregation of nimbus clouds? or is it perhaps a greater thickness of the rain vapour as seen through the long axis of the cloud? or is it possibly an alteration in the invisible vapour preparatory to a heavier precipitation? These are questions that are very difficult for a single observer to reply to. The only way to solve this problem is to have reports from accurate spectroscopists, with numerous rain-gauges stationed at various points in the surrounding country.

Many a time, whilst watching waterspouts in the tropics, I have noticed that when one increases another decreases, although a distance of several miles may separate them. This fact may probably have some bearing on the question.

The more the correlation between rainfall and rainband is considered, so much the greater seems the influence of electricity and temperature in governing the precipitation of aqueous vapour; the latter, no doubt, is a great factor, for it has frequently been remarked that a sudden reduction of temperature has produced torrents of rain with a moderately high rainband.

Here the barometer is a most reliable guide, by informing us of the increasing body of wind prevailing over the ground current, which upper current may possibly be a cold north-east or warm south-west, the glass falling with the latter and rising with the former. Another item of especial value in predicting rain is to take account of the difference between the rainband at the zenith and near the horizon; the greater the range the less likelihood of rain, and vice versâ, except in cases of low percentage. Of course, if a thick mist is prevailing, the rainband may be the same wherever you point the spectroscope; and by noticing when it lessens at the zenith, you can foretell the clearing away of the visible aqueous particles. The value for rain in the last instance depends upon the amount of rainband present.

In several mists during the last winter both Mr. Rand Capron and myself have remarked the band unusually high. The indications of the rainband in all cases will be somewhat negatived if the dry-air bands are in excess, especially the α band. I would suggest to observers, for the better comparison of rain or snow and rainband, to take frequent notes of

the temperature in the rain gauge of the rain that falls.

We will pass on now to the spectroscopic previsions of thunderstorms. The effect of these on the spectrum is to darken certain parts—for instance, the blue becomes deeper, and looks further away, the F line very indistinct, and the green apparently prominent and nearer the eye—a peculiarity I partly attribute to the increase of the rainband at w. This prominence of the green is only to be seen in spectroscopes of moderate dispersion, and not in the larger instruments. blended bands at 8 and v are much more conspicuous, and extend more towards the blue (they must not be confused with the dark band seen at 8 with low sun). The rainband may be much or little, depending greatly upon the quantity of hail and rain attending the storm. This hail in a few instances seems to veil the rain-vapour behind it from the spectroscope, and proves a disappointment to the observer who depends entirely upon the rainband. The small amount of the dry-air band at α must also be considered, and an increase of the a with less distinctness of the B. All these features make up the special spectrum noticeable more or less in advance of thunderstorms.

I well recollect one instance in which all these features were so very strongly marked at the time of observing, about 10 a.m., that I confidently prophesied a storm would take place, although none of the other instruments, nor any particular aspect of the sky, nor high temperature with oppressiveness, indicated that such an aërial disturbance was about to occur; yet certain enough, in the evening, about seven o'clock, the storm did come, much to the astonishment of a great many, including the friends with whom I was staying.

The prismatic colours, more especially the

blue and yellow, are useful guides as to the presence or absence of ozone in the air. If the air is very pure, the blue will be clear, and the r line will stand out distinctly; the yellow will show itself a true yellow, or have an orange tinge. On the other hand, when the reverse is the case, the yellow will have a greenish hue, and the blue will be deep and dark, with an indistinctness of the hydrogen line r. In most cases this peculiarity in the colours will be found to precede the atmospheric conditions.

I should recommend the observer to make it his first care, when using the spectroscope, to take note of any alteration in the true colours, as they will be found to change after looking for a short time through the instrument. The next thing is the amount of rainband (on sky free of cloud, if possible), at about 13 degrees all around, and then at the zenith. After this, begin at the blue end and work towards the red, carefully scanning the appear-

ance of the constant lines, moist and dry air bands; notice if they are clear, indistinct, hazy, well-defined, or prominent, and finish up by noting the depth of shade at the red end—for a change of weather in certain conditions of the atmosphere is frequently heralded by its becoming clearer.

For the satisfactory prediction of weather it is highly necessary to keep a record of observations on a chart and in a note-book. On the former ought to be dotted down the percentage of rainband for eight points of the compass and zenith; also that in the direction of the wind, or towards the quarter it is most likely to blow from in the course of the next twelve hours. The reason of the last is obvious, for we necessarily must expect the weather to come from that direction. In the note-book enter the peculiarities of the spectrum already noticed, and finally calculate, from what you have observed, the probabilities of rain or fine.

After a few months' practice, it is astonishing with what rapidity one can conduct a systematic observation. I use four spectroscopes of different dispersion in my atmospheric studies. A large two-prism one, with photo-



FIG. 5.

graphed micrometer (vide Fig. 5), arranged on a wooden alt-azimuth stand, with mirror for viewing the sun at different altitudes. It has three powers: the highest enlarging the rainband enormously, and enabling you to just discern two or three lines between the two p lines. A micro-spectroscope of small dispersion (Fig. 6). The first form of rainband spectroscope (Fig. 1), which, being accustomed to, I feel reluctant to disqualify



Fig. 6.

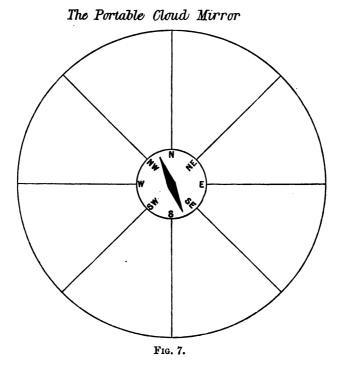
it for Grace's new and better form of hygrospectroscope (Fig. 3). To the last I have adapted a stand (originally intended to hold a condenser), to steady it and meet the requirements of altitude and azimuth. Grace's is the best all-round spectroscope, for reasons already referred to in a former page, and taken in conjunction with the other meteorological instruments will prove of great assistance to the observer in prognosticating weather.

THE PORTABLE CLOUD MIRROR.

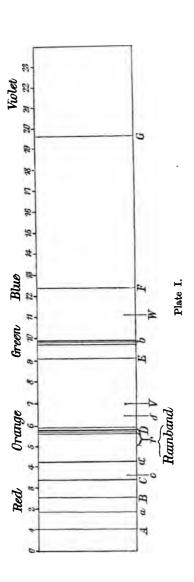
I have devised a very simple pocket cloudmirror to assist the observer in ascertaining the direction from which clouds are travelling; for it is a fact well known to meteorologists that the direction the upper clouds (cirri) are taking will often indicate the coming wind, two or three days beforehand. An outline of this apparatus is given in Fig. 7.

It is constructed of a plain circular mirror, two or three inches in diameter. Let into the centre is a small compass; from its circumference eight lines radiate to the outer edge of the reflector; the termini of these lines are equidistant from each other, and correspond to the eight points of the compass.

To use the mirror it is only necessary to



make one of the radiating lines coincide with the direction of the needle, then, if requisite, tilt the mirror, and observe the reflection of some sharp edge of cloud, and by the help of the lines notice from which direction it is travelling. This can frequently be accomplished in a few seconds.



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EXPLANATION OF THE PLATES.

Diagrams of: Percentage of cases of rain and snow for different intensities of rainband—Position of lines in spectrum—Lines forming the rainband.

PLATE I.

In this chart the actual appearances of the lines and bands of the spectrum are not intended to be represented, but merely their relative positions as seen in Grace's spectroscope. In the case of the bands, such as δ and \mathbf{v} , the line is drawn as nearly as possible in the centre of the shading.

To the red side of D will be noticed the two lines, or rather, under sufficient amplification, two sets of lines, of the principal rainband.

PLATE II.

Here are shown the vapour lines comprising the rainband. The two sets of lines before mentioned are delineated at a and b. The heavy, moderate, and slight lines are correctly placed and proportioned, and the very fine lines only approximately so. Their thickness varies with different conditions of atmospheric moisture. In the construction of the diagram a two-prism spectroscope with photographed micrometer was used, the light of the sun at a low altitude falling direct on the slit of the instrument.

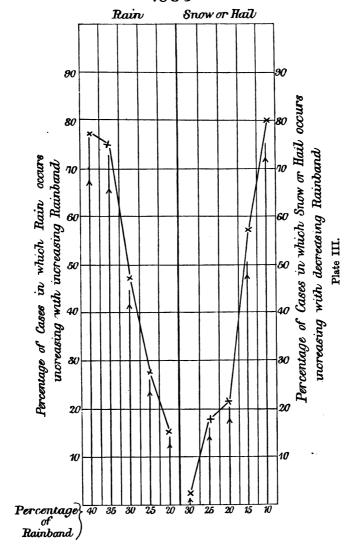
PLATE III.

The reader will see at a glance, in this Plate, the percentage of cases of rain and snow for each proportionate amount of rainband. The number of times that rain occurs within twenty-four hours increases with the darkness of the rainband, and vice versâ. On the other hand, the rainband will be

Lines in the Spectrum comprising the Principal Ranband 8-Plate II. 9 D2 D7

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observed to decrease with an increase in the number of instances in which snow falls.

There are two apparent discrepancies which demand a little explanation. I refer, firstly, to the tendency of the line on the rain side to rise at 20 per cent.; this is due to the fact that five cases of cold rain were included in the computation of the percentage; but I think it may be almost safely surmised that these five ought to have been made use of on the snow-side of the diagram, as it is highly probable that they were melted snow; if this be admitted, and the alteration made, the lines connecting the percentage will present a much more direct course. Secondly, the number of cases at 40 per cent, of rainband one would naturally expect to be more, and probably rather less at 35 per cent., than is represented. It is possible that errors in calculating amount of rainband may account for these anomalies.

The conclusions to be gathered from this diagram are the following: That where the

rainband is completely absent, snow will almost invariably occur. In all cases of 45 per cent. and upwards, rain will fall within twenty-four hours.

These lead one to the indisputable inference that the rainband increases before rain, and diminishes before snow.

APPENDIX.

THE following correspondence and leading article appeared in the Times during September, 1882. Since then the author has had, with only one exception, no reason to modify his experience as detailed in the two letters that he contributed. In the second rule of his first communication he advises, in a general way, to point the spectroscope in a northerly direction, according to the plan adopted by Professor Piazzi Smyth; but from further experience, and greater familiarity with the instrument, better results were obtained by observing towards the direction of the wind, or to the point it was most likely to change to in the course of the day. In 1882 the deductions from the hygro-spectroscope were somewhat wrapped in mystery—there

are still many points that require clearing up; but the author feels sure that the reader, by carefully attending to the rules laid down in the preceding account, will meet with success, and experience an increasing interest in the indications of an instrument of such telescopic power.

From the Times of Sept. 12th, 1882.

A correspondent writes under date Edinburgh, Sept. 8th:

'In this uncertain climate of ours—
"variable as the shade"—everything that bears on the forecasting of the weather is of interest and importance. We have not heard much hitherto of the spectroscope as a gauge of the atmosphere. In Scotland we have had this week what appears to be a very striking instance of its trustworthiness in that capacity. On Tuesday morning the following letter appeared in the Scotsman:

[&]quot;SIR,

[&]quot;Last Friday morning the spectroscopic 'rainband' was the blackest and most intense of the season; and your issue of Saturday morning announced destruc-

tive floods, from most heavy rainfalls in various parts of Scotland, to have occurred on that day—Friday.

"But this morning—Monday, September 4th—there is an absence of the 'rainband,' and a clearing away of all the watery vapour lines in the spectrum of sky-light, to an extent not equalled during the last two or three months.

"In a powerful spectroscope the two solar D lines now stand out clear and clean, in place of being almost lost, as all through last month, in a thicket of terrestrial watervapour lines. So the farmers may be enabled to gather in their crops at last, dry and in good condition, though, probably, in rather cold and sharp weather.

"I am, etc.,

'The writer is quite well known to be Mr. Piazzi Smyth, Astronomer Royal for Scotland, and Professor of Astronomy in the University of Edinburgh. How far, then, has his prediction been fulfilled? The answer is—amply up to this date. Since Sunday we have had a succession of magnificent harvest days. Tuesday morning was rather dull, and it appeared at first as if the very confident forecast were about to be belied at once; but the clouds cleared off in the forenoon, and there was brilliant sunshine with a cloudless sky

during the greater part of the day. Wednesday was a repetition of Tuesday; and as the wind blew from the north-west, the air was "rather cold and sharp," as the Professor's letter predicted. What made the case all the more curious and striking, was the fact that on both these days the forecasts of the Meteorological Office told us to expect "showery and unsettled" weather over the greater part of Scotland. The prediction for Wednesday was "fair at first, then wet and unsettled." It was more than "fair," not only "at first," but all day it was unusually bright and clear. During Tuesday and Wednesday the barometer rose steadily till it reached 30.388. It fell a little on Thursday, but it stood at 30.335 at night. The forecast of the Meteorological Office for Thursday was, "South-westerly to north-westerly winds, increasing in force; becoming unsettled and rainy." In point of fact, the wind was westerly all day; and, instead of increasing in force, it fell away toward evening to a calm. The weather did not become "unsettled and rainy;" not a drop

of rain fell all day. The evening seemed more settled than the morning; and at eleven o'clock at night the stars sparkled brilliantly, and there was not a cloud in the sky. To-day (Friday) opened with an over-clouded sky, but no rain has yet fallen, although the official forecast warns us that the day will be "fair at frst, then unsettled and rainy." As the barometer has again taken an upward turn, we may hope that this prediction will be again falsified.

'These results appear to me to be very striking and noteworthy. There has been during the week a very marked conflict of opinion between the chemists and the meteorologists, and thus far, at least, the chemists have carried the day. The practical lesson seems to be that more attention ought to be given than seems hitherto to have been the practice to the spectroscopic analysis of the atmosphere. There may have been exceptional circumstances in the atmospheric conditions of the week of which I am not aware, and which have favoured the use of

the spectroscope. But the indubitable fact remains that in this instance the spectroscopic prevision has been amply justified and proved to be correct, while the ordinary meteorological forecasts have been from day to day entirely wrong.'

From the Times of Sept. 14th, 1882.

SIR,

As the subject of forecasting rain by means of the amount of rainband in the spectroscope has been brought forward by one of your correspondents, I beg to add my quota of experience in regard to it. For the sake of brevity, I will merely give a résumé of the result of my daily examinations with this instrument.

- 1. In taking observations it is very important to have both the slit in the spectroscope and the focus properly adjusted.
- 2. In a general way it is best to confine the observations to one particular part of the sky in a northerly direction, and at an angle of between 10° and 20° from the horizon.

- 3. If the amount of rainband is 20 per cent. or under, there will be fine weather—certainly for about six hours.
- 4. If the percentage of rainband, say at 7 a.m., is 60 and at 10 a.m. it has decreased to 30, that is no reason that fine weather may follow for that day, although probably no heavy rain will take place.
- 5. If the spectroscope be directed to the zenith, and 80 per cent. of the dark band is shown, a downpour of rain will certainly happen before long. I have observed this several times with a high and steady barometer, and at the time not much appearance of rain—notably on September 5, when the spectroscope indicated rain, but the other instruments did not.

From a careful trial of this valuable adjunct to the study of weather, I have come to the conclusion that the use of it, meteorologically speaking, has been most strangely neglected; for I feel certain that our forecasts would be considerably improved if the observers at the various stations in connection with the Meteorological Office were to report at the same time with their other observations of wind, temperature, etc., the percentage of rainband in the spectroscope. The price of it places it within reach of most persons; and, as regards convenience of portableness, it is easily carried in the waistcoat pocket. Of course, a little practice is required to read the percentage of rainband, but I have found some take to it quite naturally.

I am, sir, yours obediently, F. W. Cory, F.M.S.

Buckhurst-hill, Essex, Sept. 12th.

SIR,

From the Times of Sept. 19th, 1882.

The letters which have recently appeared in the *Times* under this heading testify to so much interest in the subject, that I venture to send the following remarks, which are the result of prolonged observation on every side of the question.

But first let me explain to your general readers what the spectroscopic 'rainband' is.

If we look through a spectroscope directed to any portion of the sky, we see a spectrum tinted riband, crossed with thin black lines. One of the strongest of these, situate in the orange, is technically known as the p line. When the instrument is directed to a pure blue sky, this line is thin and faint; but in certain conditions of cloud or sky, the red side of the line has a dark shadow, as if it had been shaded down with a bit of rough black chalk. This shading is the rainband of Professor P. Smyth, who maintains that the relative darkness of this band is a measure of the nearness or quantity of rain.

Unfortunately, my own observations show that, though there is scarcely any exception to the appearance of the rainband being speedily followed by rain, yet there are numberless cases of impending or actual rain during which no band is visible: and that, at the same moment, one portion of the sky will give a band, while a neighbouring portion will show none at all. With one exception I have never seen a rainband except when

common weather lore would have said it was going to rain, while in many cases I have observed such trustworthy prognostics as haloes when no rainband was visible.

In fact, the rainband appears to be simply a new sky prognostic, in many respects inferior to those in current use, though in a few cases affording information which they do not.

Of what use is any sky prognostic in weather forecasting? The whole system of modern meteorology turns round the shape of isobaric lines as seen on charts similar to those published daily in the Times. Observation has shown that every shape of isobarics has a characteristic weather and appearance, so that there is little use in telegraphing up the occurrence of the rainband; for, given the chart, a meteorologist can write down on it not only the general weather, but the position of most of the best-known prognostics at the moment. His forecasts are based on the estimate he forms of the change which is likely to take place in the shape of the isobars during the next twenty-four hours. The

nature of these changes is still very imperfectly known, but they certainly do not admit of any mathematical calculation, like the situation of a planet. The position of a forecaster is more like that of a physician, who, although he has classified the symptoms and ordinary course of any disease, is still obliged to rely on his own judgment, to a great extent, in giving the prognosis of each particular case.

These are the principles on which the forecasts issued by the Meteorological Office are based. For the days, and at the station from which your Scotch correspondent writes, the forecasts were certainly not so successful as could be wished for, or as is usually the case. The causes of failure cannot, of course, be discussed in the columns of the *Times*; but I doubt whether the public have any idea of the difficulty of forecasting, and even of checking broken or unsettled weather like that to which he alludes. Under those conditions, rainfall is so local that half an inch may fall at one place, while twenty miles off not a drop will be seen; and from the description he

gives of his weather, I strongly suspect that, if more records were obtained from the district to which the forecasts applied, they would be found to be more successful than he is inclined to think.

Anyhow, it is certain that a forecaster who relied on the spectroscope only would meet with most disheartening failures; and though there is doubtless a rich field of research open to the student of spectral vapour lines, I fear that meteorologists have little to hope for from the spectroscope in forecasting weather.

Yours obediently, RALPH ABERCROMBY, F.M.S.

21, Chapel-street, S.W., Sept. 16th.

From the Times of Sept. 21st, 1882. SIR,

Mr. R. Abercromby's 'prolonged observation' of the spectroscope and weather forecasting must have been made with a very inefficient instrument, and with a very limited knowledge of the objects of observation; otherwise it would be difficult to understand

why he should describe the so-called rainband at D simply as a 'shading,' without reference to the very pronounced lines seen in it when there is much moisture in the air; or why he should state that Professor P. Smyth 'maintains that the relative darkness of this band is a measure of the nearness or quantity of rain.'

The Astronomer Royal for Scotland is well able to take care of himself; and I would not advert to this travesty of his teaching but that some of those who are proposing to use the spectroscope for meteorological purposes may be misled.

Aqueous vapour absorbs light at several parts of the spectrum, but principally—or perhaps I should rather say more visibly—on the red side of D, and near—on the blue side of—c. These absorptions are simply a measure of the amount of aqueous vapour in the atmosphere. (For reasons which I will not enter upon now, I believe that the absorption at the last-named portion of the spectrum, termed by Professor P. Smyth 'c,' is due to a grosser

molecule of aqueous vapour than that which absorbs near D. With a thick mist there is often an almost entire absence of absorption near D, while at c the absorption is strong. c and the band at D do not vary together.) Temperature must therefore be considered before the darkness of the rainband can be interpreted as an indication of rain.

When we remember the enormously greater thickness of the earth's atmosphere that a ray of sunlight has to traverse when we observe on the horizon than when we observe near the zenith; when we remember, further, that the wind may have just commenced to bring up quantities of aqueous vapour from a particular quarter, it will be evident that Mr. Abercromby's statement 'that at the same moment one portion of the sky will give a band, while a neighbouring portion will show none,' may be quite correct without affecting the question at issue.

I fear to trespass further on your space, but I trust I have said enough to indicate the true answers to Mr. Abercromby's difficulties. I will only point out, in conclusion, that as a knowledge of the isobars can only tell us the probable direction of the wind, a knowledge of the amount of moisture the wind is bearing—more accurate because more general than that afforded by the hygrometer—must be an important factor in weather forecasting.

I am, sir, yours obediently,

J. F. D. D.

Sept. 19th.

From the Times of Sept. 22nd, 1882.

SIR,

I can confirm all the warnings of your correspondent, Mr. Ralph Abercromby, on the difficulty and uncertainty attending spectroscopic forecasting of weather.

I have lately concluded a yachting cruise of seven weeks on the west coast of Scotland. I had with me a pocket spectroscope of admirable clearness of definition, made by Mr. Browning, of London; and I observed it frequently during all varieties of weather. I never could see that the 'rainband' had any predictive value. It was present frequently

in weather comparatively settled, and it was sometimes evanescent or absent during fine intervals of weather which was very wet and very broken.

I must add, however, that the ordinary aneroid barometer was equally useless for predictive purposes. It was unusually high for days together, during which the weather was very unsettled, with violent rain, and even some severe gales. It completely failed to indicate one gale of exceptional violence, which happened on the night of August 20; and generally I may say that throughout the season it has risen and fallen contemporaneously with the changes of weather, and not in anticipation of them.

One very remarkable fact, however, I have observed this season, as I have often observed it before—that our barometer here almost invariably indicates the raging of great gales over the western and even the southern shores of England.

Mr. Piazzi Smyth certainly made a 'good shot' in his recent letter to the Scotsman, pre-

dicting some fine dry weather from a spectroscopic forecast. And it may be that the laws regulating the appearances of the 'rainband' are yet capable of yielding good results to skilled observers. But I suspect the skill is not very easily attainable with our present knowledge. Your obedient servant,

ARGYLL.

Inverary, Sept. 20th.

From the Times of Sept. 23rd, 1882.

What may be done with the spectroscope in the matter of weather is, for the present at least, confined almost entirely to the question of rain—as, Will it rain, or will it not; and, if it will, heavily or lightly? The manner in which the spectroscope accomplishes this useful part is by its capacity for showing whether there is more or less than the usual quantity of watery vapour permeating the otherwise dry gases in the upper parts of the atmosphere, this watery vapour not being by any means the visible clouds themselves, but the invisible water-gas out of which they have to be formed, and by means of

which, when over-abundant, they obtain their privilege for enacting rainfall. So that never were wiser words uttered and more terse philosophy than those which are to be found in the ancient Book of Job, wherein, of the wondrously 'balanced clouds' high up in midair, it is said, 'They pour down rain according to the vapour thereof.'

More or less of this water-vapour is always in the air, even on the very clearest days, and a happy thing for men that it is so; for, as Dr. Tyndall and others have well shown, it moderates the excesses of hot solar radiation by day and cold radiation of the sky at night, and is more abundant in the hotter than the colder parts of the earth. Wherefore, according largely to its temperature for the time being, the air—otherwise consisting almost entirely of nitrogen and oxygen—can sustain, and does assimilate, as it were, a specified amount of this watery vapour, invisibly to the naked eye, the microscope, or the telescope; but not so to the instrument of recent times, the spectroscope. And if the air vertically above any one place becomes presently charged

with more than its usual dose of such transparent watery vapour (as it easily may, by various modes and processes of nature), the spectroscope shows that fact immediately, even while the sky is still blue; clouds soon after form, or thicken if already formed, and rain presently begins to descend.

But how does the spectroscope show to the eve what is declared to be invisible in all ordinary optical instruments? It is partly by its power of discriminating the differently coloured rays of which white light is made up, and partly by the quality impressed on the molecules of water at their primeval creation, but only recently discovered, of stopping out certain of those rays so discriminated and placed in a rainbow-coloured order by the prism and slit of the spectroscope, but transmitting others freely. Hence it is that on looking at the light of the sky through any properly-adjusted spectroscope we see, besides the Newtonian series of colours from red to violet, and besides all the thin, dark Fraunhofer, or solar originated lines, of which it is not my object now to speak, we see, I say, in one very definite part-viz., between the orange and yellow of that row of colours, or 'spectrum,' as it is called—a dark, hazy band stretching across it. That is the chief band of watery vapour; and to see it very dark, even black, do not look at a dark part of the sky or of black clouds therein, but look, rather, where the sky is brightest, fullest of light to the naked eye, and where you can see through the greatest length of such well-illumined air as at a low, rather than high, angle of altitude, and either in warm weather, or, above all, just before a heavy rainfall, when there is, and must be, an extra supply of watery vapour in the atmo-Any extreme darkness, therefore, sphere. seen in that water-vapour band beyond what is usual for the season of the year and the latitude of the place, is an indication of rainmaterial accumulating abnormally; while, on the other hand, any notable deficiency in the darkness of it, other circumstances being the same, gives probability of dry weather, or absence of rain for very want of material to make it; and the band, has, therefore, been

called, shortly, 'the rainband.' Thus, also, 'rainband spectroscopes' have been specially constructed by several most expert opticians in size so small as to be carriable in the waist-coat pocket, but so powerful and true that a glance of two seconds' duration through one of them suffices to tell an experienced observer the general condition of the whole atmosphere. Especially, too, of the upper parts of it, where any changes—as they take place there almost invariably earlier than below—enable such an observer to favour his friends around him with a prevision of what they are likely soon to experience.

As an example of what may be done, and done easily, after a certain amount of experience and understanding of the subject has been acquired, I append, from a lady's meteorological journal, her notes of the mean temperature of the air and the intensity of the rainband for each of the first fifteen days of the present month; and in a final column have entered the amount of rainfall measured at the Royal Observatory, Edinburgh, on each of those days. The darker the rainband, the

larger is the figure set down for it; and it will be seen pretty plainly, on running the eye down that column and the next one, that with an intensity of either 0 or 1 no rain follows, or, we might also say, can follow; but with an intensity of 2 rainfall begins, and with 3 it may be very heavy. All these rainband notes have been made with a spectroscope no larger than one's little finger, purchased some six years ago and taken on many voyages and travels since then:

Date, September, 1882.	Mean Tem- perature of the Air.	Rainband Intensity.	Depth of Rain measured in gauge at Royal Observatory, Edinburgh.
	Deg. Fahr.		Inch.
Friday, 1st	E 17.1	3	.044
Saturday, 2nd	59.2	2	•353
Sunday, 3rd	l ~~ ~	2	.015
Monday, 4th	يريسا	0	0
Tuesday, 5th	55.7	1	0
Wednesday, 6th	55.2	0	0
Thursday, 7th	F00	1	0
Friday, 8th	59.4	0	0
Saturday, 9th	54.0	1	0
Sunday, 10th	57.0	1	0
Monday, 11th	52.2	1	·0 4 0
Tuesday, 12th	48.6	0	0
Wednesday, 13th	52.8	1	0
Thursday, 14th	49.5	3	062
Friday, 15th	56.2	2	.570

But if so much can be done by so small a spectroscope, the question may be well asked whether more still might not be accomplished with a bigger and more powerful one, especially seeing that the dispersive powers of both chemical and astronomical spectroscopes have in late years been increased to a most astonishing extent. The question is important, and somewhat new as well. I propose, therefore, to devote the remainder of my space to its answer, rather than to the practical rules for using the smaller instruments, especially, too, as they have been already introduced to the public, both by my friend Mr. Rand Capron, in his pamphlet, 'A Plea for the Rainband,' and by myself in the fourteenth volume of the 'Edinburgh Astronomical Observations; also in the journal of the Scottish Meteorological Society, and in the September number of the 'Astronomical Register' for 1877.

The greater part of higher power spectroscopes are not suitable to rainband work, for their fields are usually too dark. But having recently built up for myself a large-sized variety of the instrument, possessing, perhaps, the greatest combination of power with transparency yet attained, and having it always mounted in an upper chamber, looking out at an altitude of about 5° over the north-western horizon (or most suitably for rainband work), I will try to describe shortly its action therein.

The classical 'rainband,' which in the little instrument is merely a very narrow fringe to an almost infinitely thin black line, is so magnified laterally in the larger instrument as to fill the whole breadth of the field. The thin black line before spoken of is now not only split into two, but each of these are strong, thick, sharply defined lines, separated from each other by six or seven times the breadth of either. These are the celebrated Solar D lines, D1 and D2, arising from the sodium metalloid burning or incandescent in the sun. They are, therefore, perfectly uninfluenced by changes of the terrestrial atmosphere, hot or cold, wet or dry, and are, therefore, invaluable as references for degree

of visibility of the water-vapour lines and bands which rise or fall in intensity precisely with those changes. There are several of these earthly water-vapour lines and bands in and between and about the D lines themselves; then a long breadth of band towards the red side of D1; then a pair of lines not so widely apart as the D lines, but sometimes just as sharp and black; then two or three fainter bands; then a grand triple, of which the nearer line sometimes attains greater blackness than either D line; then beyond that three distinct, equal-spaced, isolated bands; and further away towards the red a stretch of faint haze and hazebands.

All these go to make up the one thin rainband of the little spectroscopes; and I fortunately had, through the month of August and the early days of September, occupied myself each morning in noting the greater or less intensity of each, and all these watervapour lines and bands in terms of the two Solar constants D1 and D2; and every such morning there was an abundance of details to

busied themselves effectively while the dry weather lasted, for the return of these spectral lines of watery vapour showed that their autumn opportunity was then gone by.

C. PIAZZI SMYTH,

Astronomer-Royal for Scotland. 15, Royal-terrace, Edinburgh, Sept. 20th.

Koyai-terrace, Edinburgh, Sept. 20th.

From the *Times* of Sept. 25th, 1882. SIR,

Allow me to trespass a little further on your valuable space, as I think the difficulties the Duke of Argyll and Mr. Ralph Abercromby have experienced can be easily explained; and, moreover, it seems to me that the arguments they advance against the spectroscope for meteorological purposes rather prove the value of it than otherwise—that is to say, if used on a large scale at numerous stations. I will simply mention the following facts to bear out my statement. For instance, in the centre of a cyclone it is generally fine, and a very slight rainband may be visible in the spectroscope. In such a case, rain is, comparatively speaking, far

off. Of course, its approach to the observer depends mainly upon the rate of the progressive motion of the storm.

During wet weather the rainband is not unfrequently almost absent. This, for the most part, denotes finer weather to follow. Again, in many instances I have observed a strong rainband in beautiful weather with light and innocent-looking cumuli floating in the sky; and, as I afterwards ascertained, rain had fallen about the same time at a distance of at least ten miles from this place. I have good reason to believe from several experiments that, in whatever direction a strong rainband is shown, in such a direction rain is falling, or about to fall. The immense advantage of this indication in forecasting precipitation of aqueous vapour will be sufficiently obvious to most of your readers, so that I need not dwell any further on this point. I hope individual observers do not infer from my letter in the Times of the 14th that the spectroscope can be used alone in forecasting. I only recommended it as a

valuable adjunct to the study of the weather.

I am, sir, yours obediently, F. W. Cory, F.M.S.

Buckhurst-hill, Essex, Sept. 22nd.

From the Times of Sept. 23rd, 1882.

It is recorded of a former Minister of the United States in this country that he was asked, soon after the commencement of his sojourn among us, what he thought of the English climate. He replied that he had not experienced any climate, but plenty of weather. The abundance to which he thus bore testimony is unfortunately attended by the disadvantage of extreme irregularity; to the extent that much of the important business of life, and also many of its pleasures, are seriously hindered by the difficulty of making previous arrangements for the accomplishment of any project with which bad weather would interfere. From the gathering in of the harvest to the organization of a picnic-party, the weather either promotes or thwarts our

schemes; and hence there has never been any lack of watchfulness for conditions upon which prognostications concerning it might be safely founded. In nearly every village there is some patriarch who is popularly believed to be unusually gifted with weather wisdom, or to have paid unusual attention to slight signs which escape the unobserving, and who is consequently sought for and consulted alike by the frivolous and by the earnest. The actions of the lower animals have been studied for the sake of the powers of weather foresight which many of them are commonly believed to possess; and much popular lore of this kind has been tersely summed up by Gilbert White, in the metrical version of forty rules for predicting rain which is appended to the 'Natural History of Selborne.' More than forty years since one Murphy undertook to predict the weather for each day a whole year in advance, and issued almanack containing his predictions. Early in January one of these was fulfilled in an unexpected way, with the result that the

shop of his publisher was literally besieged by an eager crowd of would-be purchasers, by the first of whom the existing edition was speedily exhausted, with the consequence that the disappointed remainder had to be kept in order and dispersed by guardians of the public peace. A new edition was quickly prepared; but the predictions for subsequent days were less lucky, and the almanack, although issued annually for a time, soon fell into total disrepute.

Other prophets of weather have since arisen, concerning some of whom the most charitable view would be to suspect them of insanity; but it is only within the last few years that scientific observations of meteorological changes have been conducted with sufficient precision to afford hope of trustworthy results. The power conferred by the telegraph of ascertaining from hour to hour what is occurring in remote places has been utilized for the purpose of making known the weather which is apparently on its way to these latitudes; and the predictions based upon this knowledge

have been fulfilled with sufficient frequency to render it apparent that the method of inquiry is a useful one, while, at the same time, they have been falsified so often as to show that some of the causes which may interfere with the transit of weather are not yet fully understood. A storm may appear to be directly on its way to us, and yet, before it reaches our shores, it may be so deflected as never actually to arrive upon them. Until the laws of atmospheric movement have been more fully investigated, sources of error will not be entirely set aside; but the existence of these does not affect the truth that the forecasts now made are often of great practical value to the country.

Our columns have lately contained a correspondence on a new aid towards predicting weather which is manifestly worthy of attention. On Tuesday, the 5th of September, a letter, since acknowledged to have been written by Mr. Piazzi Smyth, Astronomer Royal for Scotland, appeared in the Scotsman newspaper; and in this letter the writer pre-

dicted some days of fine weather, upon the ground of the disappearance of the usual spectroscopic evidence of the presence of watery vapour in the atmosphere. His prediction, although it was opposed to the forecasts of the Meteorological Office, was justified by the event in a striking manner; and it has since given rise to an animated controversy. As a contribution to this controversy, we print to-day a letter from Mr. Smyth, in which he enters somewhat fully into the rationale of his observations; and this may be summarized in the following manner. The light which comes to us from the sun is, in fact, wave movement in an infinitely subtle fluid; and the waves are of several different rapidities of recurrence, these differences impressing the eyes differences of colour. When light is passed through a prism, the waves of the most rapid recurrence are most refracted, or bent out of their original course; while those of the least rapid recurrence are least bent; the former producing to the eye the sensation of violet, the latter the sensation of red. Intermediate between them are other colours, depending upon waves of intermediate rapidities, the general result being that the beam of light acted upon is spread out into a party-coloured band or spectrum. The light proceeding from the sun would furnish a continuous spectrum; but in passing through the solar envelopes, or through the atmosphere, some portion of it is quenched by collision with wave movement precisely of the same pitch, the waves neutralizing each other, and producing stillness, when the summits of one series fall precisely into the hollows of the other. Hence the solar spectrum is traversed by a number of dark lines in definite positions, and one of these, which appears single in small instruments, although in larger ones it admits of separation into constituent parts, is due to the presence of watery vapour in the atmosphere. Mr. Smyth points out that this watery vapour is, so to speak, the raw material of rain, and that without it rain cannot be produced. He therefore infers that its total absence involves of necessity a period of dry weather, and that its marked presence indicates a state of things in which the material for rain is abundant, and in which rainfall must, therefore, be regarded as highly probable.

Assuming the facts to be as stated, the letters of the correspondents who have expressed doubts of the utility of the spectroscope as a means of predicting weather do not appear to possess much value. No scientifically instructed person would expect the degree of abundance of watery vapour to be alone conclusive with regard to a result which no doubt depends partly upon this, and partly upon the concurrence of many variable factors. Watery vapour may be absent at a given moment, or in a given direction, and may be rapidly brought from elsewhere, just as in all probability it may sometimes be rapidly conveyed away, by atmospheric movement, without occasioning rainfall in a place where it was actually detected.

The condition first described by Mr. Smyth, in which the spectroscopic vapour-band had

absolutely disappeared, is not likely to be of frequent occurrence; and it would probably be only something as marked as this which would justify a conclusion based upon one element of the question. The real value of the spectroscope to meteorologists has yet to be ascertained, and must depend upon the power which it promises to afford of determining the amount or proportion of watery vapour in the atmosphere at a given time, and possibly also the molecular state of this vapour, and of adding the facts thus made known to any others which may be available for the purposes of the inquiry.

Temperature must always constitute an important element in predictions founded upon the presence of watery vapour, because an ordinary immediate cause of rain is the arrival of moisture-laden air in a region colder than that from which it came. It is not likely that much will ever be learned from isolated observations, taken with small instruments, by which the precise composition of the vapour-band is not disclosed, or taken with-

out reference to conditions which may co-exist in other localities.

Enough has at least been made out to show that the observation of the vapour-band is one which cannot be neglected for the future; and it will be time to decide upon the precise import of the appearances which this band may present when they have been studied over extended areas, and with proper reference to all associated phenomena. The progress lately made in forecasting weather is sufficient to justify great hope of further advances in the same direction; but it is not sufficient to permit the neglect of any method of inquiry which promises to render our knowledge of any factor in the production of rainfall at all more methodical or complete.

THE END.

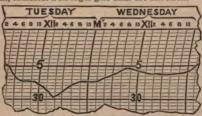
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